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# 1.0 Introduction

Business Aviation has established a record as one of the world's safest forms of transportation. Professionally flown aircraft of all sizes are operated on unscheduled routes to all corners of the globe, yet the safety record continues to be excellent in spite of the very challenging operating environment.

The exemplary safety record of business aviation can be attributed to professionalism and attention to safe operating practices. The business aviation community promotes safety through industry standards and good training, as well as through monitoring and analysing safety information to facilitate continuous improvement. The business aviation representative associations assist operators by providing safety data and programs in their respective countries. The Council representing the national and regional associations at the global level, the International Business Aviation Council (IBAC), has in turn developed a program to collect and analyse worldwide information. To that end, IBAC has contracted with Robert Breiling and Associates to develop global data on business aircraft accidents.

Summary information presented in this Brief is taken from the analysis conducted by Robert Breiling and Associates in 2010. Breiling's detailed Report contains information on accidents from all regions of the world.

This Business Aviation Safety Brief covers a five year period from 2005 to 2009. IBAC will update the Brief annually and the IBAC Planning and Operations Committee (POC) will review the information continuously to determine useful trend data. In addition, the IBAC Governing Board has determined that the Safety Brief will be scrutinized from time to time by independent organizations and feedback will be considered by IBAC's POC.

This summary data includes all accidents involving aircraft when used in conducting business operations. It does not include accidents of business aircraft when used in airshows and other non-business related flying.

Listings of Business Jet and Turboprop accidents that occurred in the preceding calendar year (i.e. 2009) are contained in Appendices A & B.

The compilation, analysis and publication of safety data is an essential foundation for the development of measures to prevent accidents and thus, is not a means unto itself. In this regard, and as a separate IBAC initiative, the International Standard for Business Aircraft Operations (IS-BAO) was introduced in 2002 and was designed to raise the safety bar by codifying safety best practices.

Recognizing that it will be many, many years before safety data will reflect the impact of the IS-BAO, IBAC commissioned an independent, retrospective analysis to subjectively assess the extent to which (i.e. in terms of probability) had the IS-BAO been implemented by the operator concerned the accident could have been prevented. A synopsis of the findings of this study are presented in Section 5.0.

## 2009 Highlight Summary

*In previous editions of the Safety Brief the editors have refrained from providing comment and information pertaining to annual safety data and performance.*

*The five year moving average analysis has and will continue to provide a realistic 'measure' of performance. Moreover, until 2009, annual data did not warrant particular comment or high-lighting. As will be evident from the summary below, such is not the case for 2009.*

The business aviation global fleet increased by 4.4% in 2009, comprising an increasing in jets of 5.4% and turboprops 3.1%.

Flight hours in 2009 increased by 3.1% overall, with jets accounting for an increase of 2.6% and turboprops a decrease of 4.3%.

In calendar year 2009 the number of accidents involving business aircraft (jets and turboprops) decreased by 27.9% (101 cf 140) from those in the previous calendar year.

Fatal accidents decreased by 34.1% over the same period.
Accidents involving jets decreased by 44.2% (24 cf 43) and turboprops 20.6% (77 cf 97).

# 2.0 Business Aviation Community

## 2.1 Number of Turbine Aircraft

The Breiling Report contains data covering a five year period for the global population and the distribution of aircraft by region. A summary of the aircraft population in 2009, the last year covered by the report, is as follows:

| 2009<br>Global Business Aircraft Population | |
|---|---|
| Business Jets | 17,382 |
| Turbo Props | 12,499 |
| All Turbine Business A/C | 29,881 |

**Table 2.1a**

**Analysis**

Business aircraft in North America represent 63.7% of the global fleet. South and Central America have approximately 11.8% and Europe 13.9% of the world's fleet. Other regions account for the remaining 10% of the fleet.

## 2.2 Number of Flight Hours

The 2009 summarized flight hour totals are as follows:

| 2009<br>Global BusAv Flight Hours | |
|---|---|
| Business Jets | 6,421,479 |
| Turbo Props | 4,796,390 |
| All Turbine Business A/C | 11,217,867 |

**Table 2.2a**

**Analysis**

For the period 2005-2009, flying hours in North America represents 62.7% of the total, Europe 13.2%, Central/South America 11.8%, and the rest of the world 12%.

## 2.3 Number of Departures

The number of business aviation departures in the 2009 year is as follows:

| 2009<br>Global BusAv Departures | |
|---|---|
| Business Jets | 4,510,459 |
| Turbo Props | 3,229,114 |
| All Turbine Business A/C | 7,739,573 |

**Table 2.3a**

(*Note: These are derived figures based on flight hours and sector durations typical for each category of jet and turboprop aircraft.*)

## 2.4 Organization of the Community

Business Aircraft operations are classified into three (3) separate categories:

1. **Business Aviation Commercial**
Aircraft flown for business purposes by an operator having a commercial operating certificate (generally on-demand charters).

2. **Corporate**
Non-commercial operations with professional crews employed to fly the aircraft.

3. **Owner Operated**
Aircraft flown for business purposes by the owner of the business.

*(Note : Consult IBAC for formal definitions of the three categories. Two additional classifications are included in the Breiling Report, namely Government (public operations) and Manufacturer aircraft. These are not, by their use, considered to be “business aircraft”, but are included in the data for completeness.)*

# 3.0 Business Aircraft Global Accident Data

**(5 year period 2005 – 2009)**

## 3.1 Accidents by Operator Type

A summary of the total accidents over five (5) years by type of operator is as follows:

| Accidents by Operator Type - Jet Aircraft | | | | |
|---|---|---|---|---|
| Business Jet Aircraft | Total Accidents (5 yrs) | Fatal Accidents (5 yrs) | Average Total Accidents per year | Average Fatal Accidents per year |
| Commercial | 91 | 23 | 18.2 | 4.6 |
| Corporate | 45 | 5 | 9.0 | 1.0 |
| Owner Operated | 18 | 4 | 3.6 | 0.8 |
| Government | 6 | 2 | 1.2 | 0.4 |
| Fractional | 7 | 0 | 1.4 | 0 |
| Manufacturer | 1 | 0 | 0.2 | 0 |

**Table 3.1a**

| Accidents by Operator Type - Turbo Prop Aircraft | | | | |
|---|---|---|---|---|
| Turbo Prop Aircraft | Total Accidents | Fatal Accidents | Average Total Accidents per year | Average Fatal Accidents per year |
| Commercial | 214 | 61 | 42.8 | 12.2 |
| Corporate | 30 | 8 | 6.0 | 1.6 |
| Owner Operated | 105 | 37 | 21.0 | 7.4 |
| Government | 10 | 3 | 2.0 | 0.6 |
| Manufacturer | 2 | 1 | 0.4 | 0.2 |

**Table 3.1b**

*(Note: No analysis provided for **Fractional** operations conducted with **Turbo Prop Aircraft**.)*

### Analysis

The majority of business aircraft accidents occur in the commercial category, where operations are governed by commercial regulations (such as FAA Part 135 and JAR OPS 1). The next most frequent number of accidents occurs with aircraft flown by business persons. Accidents of corporate aircraft remain rare.

## 3.2 Accident Summary by Phase of Flight

Five (5) year totals by phase of flight are as follows:

| Accident Summary by Phase of Flight | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Taxi | T/O | Climb | Cruise | Desc't | Man'v | App | Land | Total |
| Business Jets | 15<br>8.9% | 20<br>11.8% | 10<br>5.9% | 8<br>4.7% | 6<br>3.6% | 2<br>1.2% | 15<br>8.9% | 93<br>55.0% | 169<br>100% |
| Turbo Props | 17<br>4.4% | 29<br>7.6% | 39<br>10.2% | 38<br>9.3% | 8<br>2.1% | 20<br>5.0% | 69<br>16.1% | 164<br>42.7% | 384<br>100% |

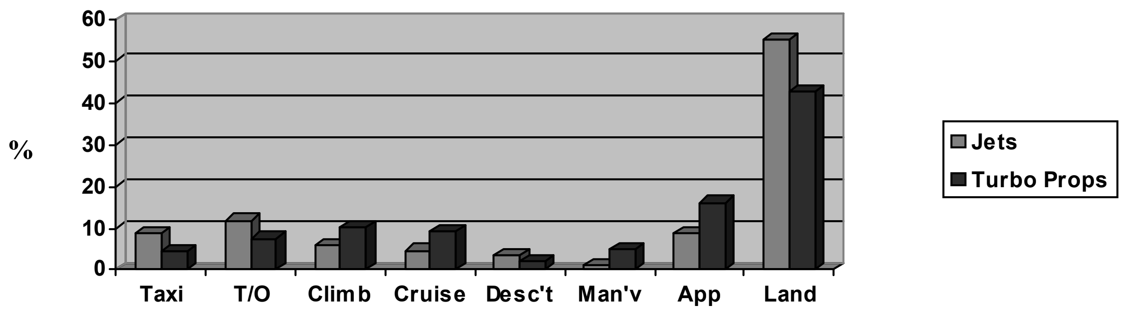



**Table 3.2a**

### Analysis

The trend over a period of 35 years demonstrates a substantive decrease in the percentage of taxi accidents, and a notable decrease in accidents in the landing phase, although landing accidents remain as the most prevalent.

The trend indicates an increase in the number of accidents occurring in the approach phase. The percentage of accidents in the climb phase has also increased substantively for turbo prop aircraft. The distribution of accidents in the other phases has remained relatively unchanged.

*(Note: Supplementary data collected by Robert Breiling over a 35 year period was used to develop this trend.)*

# 4.0 Global Accident Rate Data

## 4.1 Accident Rate by Aircraft Type

The accident rate per 100,000 flight hours for each year over a five year period, as well as for the total, is as follows:

| Accident Rate per 100,000 hours by Aircraft Type | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | | 2006 | | 2007 | | 2008 | | 2009 | | **5 Year Total** | |
| | Acc Rate | Fatal Rate | Acc Rate | Fatal Rate | Acc Rate | Fatal Rate | Acc Rate | Fatal Rate | Acc Rate | Fatal Rate | **Acc Rate** | **Fatal Rate** |
| Business Jets | 0.56 | 0.13 | 0.69 | 0.13 | 0.63 | 0.13 | 0.69 | 0.14 | 0.37 | 0.08 | **0.64** | **0.14** |
| Turbo props | 1.46 | 0.39 | 1.39 | 0.41 | 1.6 | 0.56 | 2.11 | 0.78 | 0.70 | 0.46 | **1.72** | **0.52** |
| All Bus A/C | 0.98 | 0.25 | 1.01 | 0.26 | 1.05 | 0.32 | 1.29 | 0.38 | 0.90 | 0.24 | **1.13** | **0.32** |

**Table 4.1a**

*Note: Some of the above figures have been re-stated as a result of the availability of subsequently published accident investigation reports and/or additional information.*

## 4.2 Accident Rate by Operator Type

Global data for the numbers of aircraft in each of the business aviation operational categories (commercial, corporate and owner-operated) proved difficult to obtain as few States collect this information. Similarly, flight hours by type of operation are not available. Due to the lack of good exposure data, it was not possible to calculate, without some error, the rate of each category of operation. Additionally, the operational status of a single airframe may legally vary from flight to flight (i.e., an aircraft may be commercial on one flight and private on a flight made later on the same day or vice versa).

Nevertheless, by applying US data relevant to the division between categories of operator, and by making the assumption that the division is relatively similar for the rest of the world, an estimate of the rate by operator type can be made. Given that the North American data represents approximately 64% of the global total, it is unlikely that the distortion generated by the assumption will be very large.

The percentage of flight hours for each of the three categories in the USA is as follows:

| | |
|---|---|
| Commercial (Air Taxi) | 30.4% |
| Corporate | 55.3% |
| Owner-operated | 14.3% |

*Ed note:*
*Additional information is provided at Appendix C. The profiling for the above three categories has changed significantly from that in all Safety Briefs prior to Issue 7. Consequently the data presented in the tables which follow cannot be directly compared with that in the same tables in previous edition of the Safety Brief, and vice versa.*

Assuming a similar division globally, the accident rates per 100,000 flight hours are as follows (based on data over 5 years):

| **Global Accident Rates by Operator Type** *(Extrapolated)* *(per 100,000 flight hours)* **All Business Aircraft** | | | | | |
|---|---|---|---|---|---|
| Operator Type | Hours of Operation (5 yrs) | Total Accidents | Fatal Accidents | Total Accident Rate | Fatal Accident Rate |
| Commercial (Air Taxi) | 15,038,955 | 305 | 85 | 2.03 | 0.56 |
| Corporate | 27,357,047 | 75 | 13 | 0.27 | 0.05 |
| Owner-operated | 7,074,245 | 123 | 41 | 1.74 | 0.58 |
| *All Business Aircraft | 49,470,249 | 558 | 157 | 1.13 | 0.32 |

**Table 4.2a**

*Note: *This line includes the three lines above it, plus **Government**, **Manufacturers** and **Fractional** aircraft operators. Also included are accidents involving operators for which insufficient information was available to assign the operator type.*

| **Global Accident Rates by Operator Type** *(Extrapolated)* *(per 100,000 flight hours)* **Jet Aircraft** | | | | | |
|---|---|---|---|---|---|
| Operator Type | Hours of Operation (5 yrs) | Total Accidents | Fatal Accidents | Total Accident Rate | Fatal Accident Rate |
| Commercial (Air Taxi) | 8,246,991 | 91 | 23 | 1.10 | 0.28 |
| Corporate | 15,001,928 | 45 | 5 | 0.30 | 0.03 |
| Owner-operated | 3,797,956 | 18 | 4 | 0.47 | 0.10 |
| *All Business Aircraft | 27,128,261 | 174 | 39 | 0.64 | 0.14 |

**Table 4.2b**

*Note: *This line includes the three lines above it, plus **Government**, **Manufacturers** and **Fractional** aircraft operators. Also included are accidents involving operators for which insufficient information was available to assign the operator type.*

| **Global Accident Rates by Operator Type** *(Extrapolated)* *(per 100,000 flight hours)* **Turbo Prop Aircraft** | | | | | |
|---|---|---|---|---|---|
| Operator Type | Hours of Operation (5 yrs) | Total Accidents | Fatal Accidents | Total Accident Rate | Fatal Accident Rate |
| Commercial (Air Taxi) | 6,791,964 | 214 | 61 | 3.15 | 0.90 |
| Corporate | 12,355,119 | 30 | 8 | 0.24 | 0.06 |
| Owner-operated | 3,194,904 | 105 | 37 | 3.28 | 1.16 |
| *All Business Aircraft | 22,341,988 | 384 | 118 | 1.72 | 0.53 |

**Table 4.2c**

*Note: *This line includes the three lines above it, plus **Government**, **Manufacturers** and **Fractional** aircraft operators. Also included are accidents involving operators for which insufficient information was available to assign the operator type.*

## Analysis

The accident rates calculated in Table 4.2 include both turbo-prop and jet aircraft. The rate data indicates an excellent level of safety in corporate operations, whereas the accident rates in the commercial sector warrants increased attention by the business aviation community.

## 4.3 Accident Rate by Departures

There is a growing trend for organizations reporting safety data to do so using accident rates per number of departures given that safety exposure is greatest during departure and arrival. Accidents of aircraft en-route are rare except for flights in low level flight in marginal visual conditions. Accident rates per departure, or flight segment or cycle, therefore provide more realistic safety correlations.

*Ed note:*
*Additional information is provided at Appendix C. The profiling for the above three categories has changed significantly from that in all Safety Briefs prior to Issue 7. Consequently the data presented in the tables which follow cannot be directly compared with that in the same tables in previous edition of the Safety Brief, and vice versa.*

The accident rate per 100,000 departures is as follows:

| **Business Jet Accident and Rate by Departures** *(per 100,000 departures)* | | | | | |
|---|---|---|---|---|---|
| Accident Rate | Departures | Accidents (5 Years) | | Accident Rate | |
| | | Total | Fatal | Total | Fatal |
| Large Jet Aircraft | 4,965,491 | 33 | 5 | 0.66 | 0.10 |
| Medium Jet Aircraft | 5,623,724 | 51 | 12 | 0.91 | 0.21 |
| Light Business Jets | 8,785,105 | 90 | 22 | 1.02 | 0.21 |
| *All Business Jets | 19,074,320 | 174 | 39 | 0.91 | 0.20 |

**Table 4.3a**

| **Business Turbo Prop Accidents and Rates by Departures** *(per 100,000 departures)* | | | | | |
|---|---|---|---|---|---|
| | Departures | Accidents (5 Years) | | Accident Rate | |
| | | Total | Fatal | Total | Fatal |
| Large Turbo Prop | 1,001,812 | 69 | 21 | 6.89 | 2.10 |
| Medium Turbo Prop | 13,228,045 | 280 | 87 | 2.12 | 0.66 |
| Light Turbo Prop | 811,630 | 35 | 10 | 4.31 | 1.23 |
| All Turbo Prop | 15,041,487 | 384 | 118 | 2.55 | 0.78 |

**Table 4.3b**

| **All Business Turbine Accidents and Rates by Departures** *(per 100,000 departures)* | | | | | |
|---|---|---|---|---|---|
| | Departures | Accidents (5 Years) | | Accident Rate | |
| | | Total | Fatal | Total | Fatal |
| All Business Aircraft | 34,115,807 | 558 | 157 | 1.64 | 0.46 |

**Table 4.3c**

If an assumption is made that the distribution of departures for operator types of commercial (30.4%), corporate (55.3%) and owner-operated (14.3%) is relatively the same as the distribution between flight hours, the accident rates by type of operation can be calculated as follows:

| **Business Aircraft Accident Rates by Operator Type** *(Extrapolated)* *(per 100,000 departures)* | | | | | |
|---|---|---|---|---|---|
| Operator Type | Departures (5 yrs) | Total Accidents | Fatal Accidents | Total Accident Rate | Fatal Accident Rate |
| Commercial (Air Taxi) | 10,371,205 | 305 | 85 | 2.94 | 0.82 |
| Corporate | 18,866,041 | 75 | 13 | 0.40 | 0.07 |
| Owner-operated | 4,878,560 | 123 | 41 | 2.52 | 0.84 |
| *All Business Aircraft | 34,115,807 | 558 | 157 | 1.64 | 0.46 |

**Table 4.3d**

| Business Aircraft Accident Rates by Operator Type (Extrapolated) *(per 100,000 departures)* **Jet Aircraft** | | | | | |
|---|---|---|---|---|---|
| Operator Type | Departures (5 yrs) | Total Accidents | Fatal Accidents | Total Accident Rate | Fatal Accident Rate |
| Commercial (Air Taxi) | 5,798,593 | 91 | 23 | 1.57 | 0.40 |
| Corporate | 10,548,098 | 45 | 5 | 0.43 | 0.05 |
| Owner-Operated | 2,727,628 | 18 | 4 | 0.66 | 0.15 |
| *All Business Aircraft | 19,074,320 | 179 | 39 | 0.94 | 0.20 |

**Table 4.3e**

| Business Aircraft Accident Rates by Operator Type (Extrapolated) *(per 100,000 departures)* **Turbo Prop Aircraft** | | | | | |
|---|---|---|---|---|---|
| Operator Type | Departures (5 yrs) | Total Accidents | Fatal Accidents | Total Accident Rate | Fatal Accident Rate |
| Commercial (Air Taxi) | 4,572,612 | 214 | 61 | 4.68 | 1.33 |
| Corporate | 8,317,942 | 30 | 8 | 0.36 | 0.10 |
| Owner-Operated | 2,150,933 | 105 | 37 | 4.88 | 1.72 |
| *All Business Aircraft | 15,041,487 | 384 | 118 | 2.55 | 0.78 |

**Table 4.3f**

## Analysis

A number of assumptions have been made related to the distribution of exposure data, and as a result the data should be used with some caution. Nevertheless, no other rate data is known to exist for worldwide business aviation. The results of the extrapolation should be sufficiently accurate to provide a reasonable comparison with accident information from other aviation sectors.

## 4.4 Comparison With Other Aviation Sectors

IBAC is experiencing increasing difficulty in drawing meaningful comparisons of business aviation safety data i.e. accident rates per 100,000 departures with those developed and published for other sectors of the aviation community. The incongruencies inhibiting such comparisons include; operational classification i.e. commercial vs. non-commercial, classification of accidents involving fatalities i.e. passengers only or crew, hull loss accidents, range of aircraft MCTOM encompassed by the data, lack of disaggregation by power plant i.e. turbojet, turboprop or recips etc. While it is unlikely that these incongruencies can ever be fully reconciled, IBAC is making every effort to understand and identify these factors and will continue to promote international recognition of the IBAC safety data.

| Aviation Sector | Fatal Accident Rate (per 100,000 departures) |
|---|---|
| All Business Aircraft (Jet and Turbo Prop)* | 0.46 |
| Corporate Aviation (Jet and Turbo Prop)** | 0.07 |
| All Business Jets*** | 0.20 |
| Boeing Annual Report – Jet aircraft MCTOM over 60,000lbs engaged in commercial scheduled passenger operations.**** | 0.048 |

**Table 4.4a**

* Per Table 4.3c. IBAC rate is 5 year average.
** Per Table 4.3d. IBAC rate is 5 year average.
***Per Table 4.3a. IBAC rate is 5 year average.
**** Boeing – Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations 1959-2008. Rate is for a 10 year period, 2000-2009

# 4.5 Accident Rate Trend

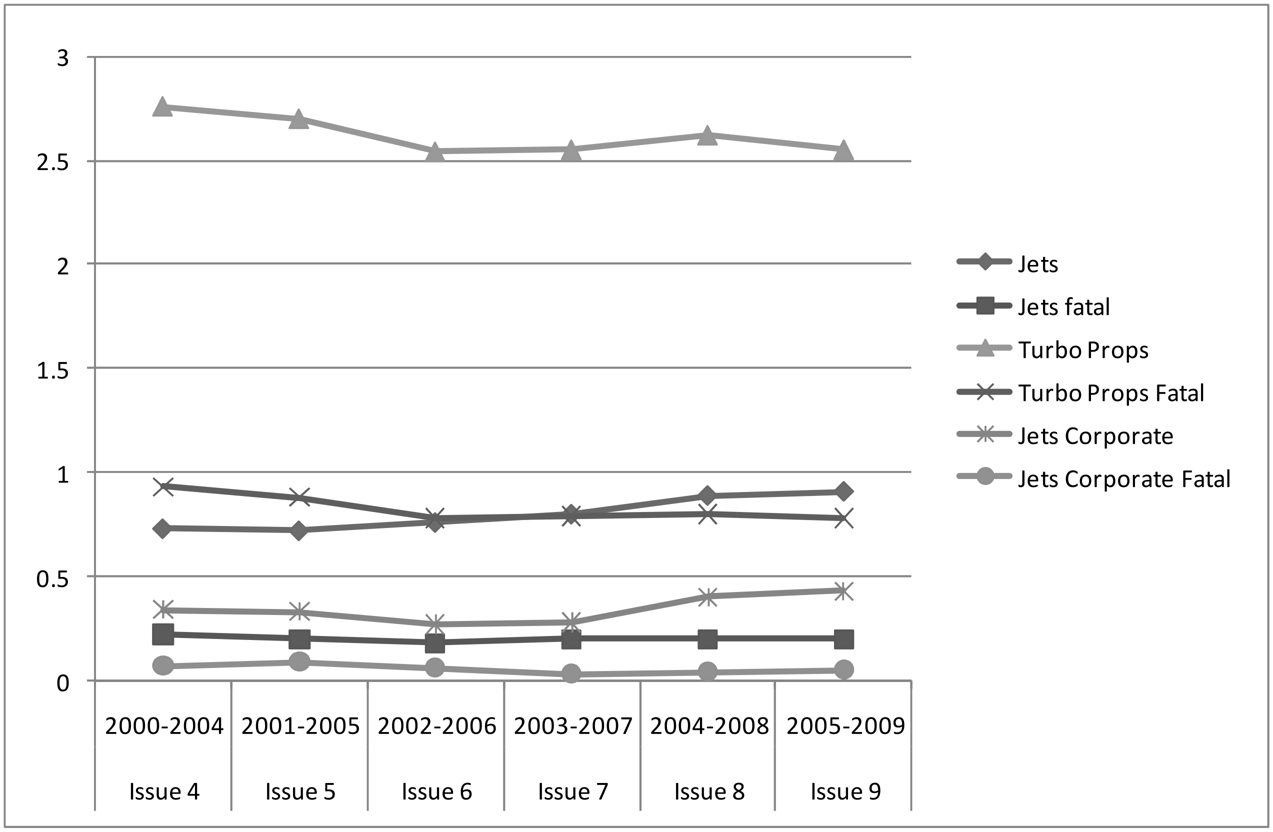



**Table 4.5a**
**Accident rate per 100,00 departures**

# 5.0 IS-BAO Safety Value

## A Code of Practice

The International Standard for Business Aircraft Operations (IS-BAO) is an industry safety standard introduced in 2002 as the industry's code of practice designed to raise the safety bar by codifying safety best practices. Given that there are very few accidents in the business aviation community, it will be many years before a determination can be made regarding whether or not the IS-BAO is making a safety impact. Therefore, to assess the safety value a study was initiated based on historical accident data.

An analysis of past accidents required a considerable amount of subjective assessment as the analysts had to review the details of accidents against a full understanding of the IS-BAO to make a value judgment regarding whether the accident may have been avoided if the IS-BAO had been implemented.

The study was conducted by an independent analyst who reviewed a total of 500 accidents covering the period between 1998 and 2003. A total of 297 accidents of the 500 were considered to contain sufficient information to be further assessed. The study against the provisions of the IS-BAO standard was performed to determine a level of probability that if the flight department had known about and implemented the IS-BAO the accident may have been avoided. The data was classified and analyzed to determine the potential impact of the IS-BAO and the accidents were rated on a five point scale ranging from certainty of prevention to no effect.

Two assessments were made. First, the analysts made the assumption based on indicators that the flight department may have implemented the IS-BAO, and if implemented, the potential for accident avoidance. The accidents were then further analyzed to determine the potential outcome given that the IS-BAO was implemented in full before the accident. An audit by an accredited auditor leading to an IBAC Certificate of Registration is the recommended means of demonstrating full implementation.

As part of the analysts' work, the accidents were classified in a number of different ways to see if there were any meaningful trends in the prevention probability between the different factors. Classification methodologies applied include:

1. Simple Four Factors – Human, Technical, Environmental and Management.
2. Events – or significant type of accident (such as loss of control).
3. Breakdown on Human Factors.
4. Boeing Accident Prevention Strategies.

Probabilities were calculated for all accidents, phase of fight, type of accident, four factors (per above), type of operation, Commercial or non-commercial, fatalities and single versus two pilot operations.

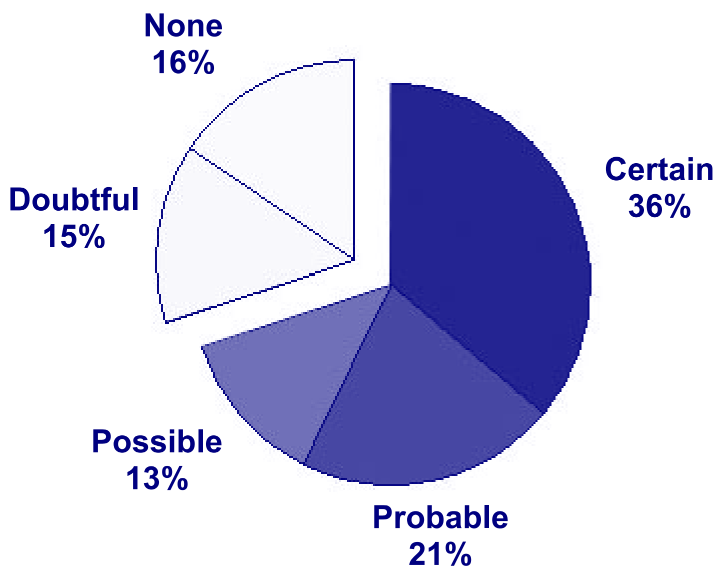
A further step in the methodology included a quality assurance analysis by a group of current pilots through an assessment of a random selection of twelve accidents as a means of verifying the results of the analysts.

# Results of Analysis

**Criteria A**
Assumes Operators Had Completely Implemented IS-BAO Prior to the Occurrence.

This part of the analysis made the assumption that the operator had implemented the IS-BAO standard in full. An assessment was then made regarding the potential that the accident could have been prevented. The following were the results of the assessment.

| | |
|---|---|
| Certain of prevention | 36.0% (107 of 297 accidents) |
| Probable prevention | 21.2% (63 of 297) |
| Possible prevention | 12.8% (38 of 297) |
| Doubtful of prevention | 14.5% (43 of 297) |
| No prevention possibility | 15.5% (46 of 297) |

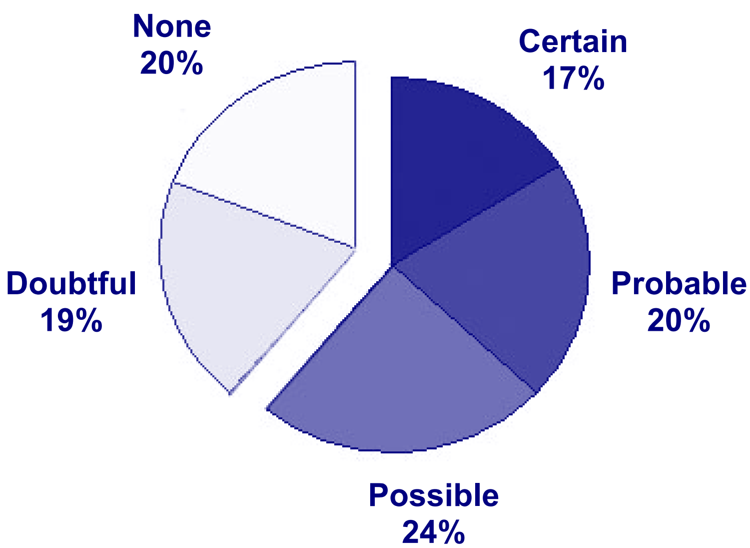



Conclusion - The probability of prevention is 57.2%, with a further 12.8% possible for a total of 70% potential that the aircraft accident could have been avoided.

**Criteria B**
Takes into Account Operators Background and Probability of Introduction of IS-BAO.

The assessment of whether the accident may have been prevented if the flight department had known about the IS-BAO, and if the operator was sufficiently responsible to implement the standard and had done so thoroughly, produced the following results:

| | |
|---|---|
| Certain of prevention | 17.2% (51 of 297 accidents) |
| Probable prevention | 20.2% (60 of 297) |
| Possible prevention | 23.9% (71 of 297) |
| Doubtful of prevention | 19.2% (57 of 297) |
| No prevention possibility | 19.5% (58 of 297) |




Conclusion - The probability of prevention is 37.4%, with a further 23.9% possible for a total of 61.3% potential that the aircraft accident could have been avoided.

**Criteria C**
Probability of Prevention by Types of Operation and Aircraft.

The analysis showed that there is a greater probability that the accident could have been prevented for jet aircraft type accidents versus turboprop. This was a trend consistent through most methods of analysis and type of accident, although in some cases there was little to distinguish between jet and turboprop probabilities. For example, for the landing accidents (the most common type of accident) the probability of prevention was much greater for jets than turboprop aircraft. Yet, for loss of control accidents there was substantially no difference. The reason for the difference considered by the analysts was that there would be a greater potential for prevention in two pilot operations more typical in jet aircraft.

As would be expected there was a significantly greater probability of prevention related to Management Factors compared to Environmental factors, whereas Technical Factors and Human Factors ranked in the middle of these two.

There was no significant difference between the probability of prevention of commercial operations (air taxi) versus non-commercial. Evidence indicates that there is a higher probability that IS-BAO implementation would prevent accidents with two pilot operations versus one pilot.

Accidents with causal factors related to human performance totaled 232, and were broken down into the following;

| | | |
|---|---|---|
| 1. | Knowledge Based (no standard solution) | 37 |
| 2. | Rule Based (need to modify behaviour) | 46 |
| 3. | Skill Based (routine practiced tasks) | 149 |

There was no significant difference between the probability of prevention between these three categories.

## Conclusion

The study by an independent analyst indicates that the IS-BAO standard has considerable potential to improve safety. The extent of potential benefit depends significantly on the commitment of the operator to implement and adhere to the standard.

# Appendix A

## 2009 Business Jet Accidents (World)

| Date | Model | Description | Region | Phase | Operator | Fatalities |
|---|---|---|---|---|---|---|
| 1/3/2009 | L-45XR | Aircraft landed to side of the snow covered runway, Telluride, CO | N.A. | Landing | Comm | No |
| 1/4/2009 | CE-650 | Acft. drifted off runway side landing on wet/slick runway, night | C.A. | Landing | Comm | No |
| 1/4/2009 | CE-550 | Aircraft landed gear up after 3 approaches in below min. wx. | C.A. | Landing | Corp | No |
| 1/16/2009 | G-200 | Aircraft ran off runway side landing in poor wx. and fog | Europe | Landing | Comm | No |
| 1/27/2009 | CE-560 | Main gear failed to extend due hyd. malf/fail. & landed gear up | Europe | Landing | Comm | No |
| 2/5/2009 | L-35 | Control lost on landing, aircraft slid off runway collapsing gear | C.A. | Landing | Comm | No |
| 2/7/2009 | CE-650 | Aircraft impacted terrain shortly after takeoff in VMC | Europe | Climb | Comm | Yes |
| 2/12/2009 | DA-100 | Wing hit snow berm on landing causing aircraft to cartwheel | Europe | Landing | Comm | Yes |
| 2/24/2009 | L-35A | Right wingtip struck runway during landing | N.A. | Landing | Corp | No |
| 3/17/2009 | L-55 | Main tires failed and caught fire during 2nd takeoff, TO aborted | N.A. | Takeoff | Comm | No |
| 3/29/2009 | CE-550 | Aircraft veered off runway side collapsing the right main gear | N.A. | Landing | Corp | No |
| 5/5/2009 | CE-551 | Aircraft experienced a rapid loss of altitude but landed safely | N.A. | Cruise | Pvt/Bus | No |
| 6/18/2009 | L-40XR | Aircraft landed to side of the runway at Telluride, snow covered | N.A. | Taxi | Comm | No |
| 8/15/2009 | HS-800XP | Substantial damage discovered from a prior hard landing | Europe | Landing | Comm | No |
| 8/21/2009 | CE-510 | Aircraft landed gear up, aborted, lowered gear and re-landed | Asia | Landing | Comm | No |
| 9/27/2009 | CL-600-2B | Aircraft landed hard due to windshear | N.A. | Landing | Corp | No |
| 10/8/2009 | CE-550 | Aircraft impacted signs taking off on side of runway, day, VMC | N.A. | Takeoff | Public | No |
| 10/12/2009 | EMB-100 | Aircraft overshot 3,100 ft. runway | S.A. | Landing | Corp | No |
| 10/26/2009 | HS-800B | Aircraft crashed in forest 3 mi. short on approach in IMC | Europe | Approach | Comm | Yes |
| 11/11/2009 | DA-2000 | Aircraft damaged by brake fire during maintenance test | Europe | Taxi | Frax | No |
| 11/18/2009 | DA-900 | Landing overshoot, nose gear collapsed in gusting conditions | C.A. | Landing | Comm | No |
| 11/19/2009 | IAI-1124A | Aircraft ditched in ocean following fuel exhaustion and poor wx. | Oceania | Landing | Comm | No |
| 12/18/2009 | DA-20 | Acft. crashed off Great Inagua Island out of control at night, VMC | N.A. | Cruise | Comm | Yes |

# Appendix B

## 2009 Business Turbo Prop Accidents (North American Registered)

| Date | Model | Description | Region | Phase | Operator | Fatalities |
|---|---|---|---|---|---|---|
| 1/11/2009 | PC-12 | Crashed shortly after takeoff in IMC and in heavy snow | N.A. | Climb | Pvt/Bus | Yes |
| 1/11/2009 | PA-46-500TP | Pilot bailed out to hide identity, acft crashed out of fuel | N.A. | Cruise | Pvt/Bus | No |
| 1/14/2009 | BE-1-ODA | Aircraft veered off runway side during takeoff, due unkn. cause | N.A. | Takeoff | Comm | No |
| 1/16/2009 | BE-100 | Aircraft hit trees during late missed approach in IMC | N.A. | Approach | Comm | No |
| 1/15/2009 | AC-690C | Aircraft pitched over during final approach to land in IMC | N.A. | Approach | Corp | Yes |
| 2/4/2009 | PA-46-500TP | Aircraft veered off runway side due to a canted nose wheel | N.A. | Landing | Pvt/Bus | No |
| 2/16/2009 | BE-A90 | Acft. sled to side of snow covered runway in night conditions | N.A. | Landing | Pvt/Bus | No |
| 2/23/2009 | PA-31T | Prop hit runway and airplane porpoised during landing | N.A. | Landing | Pvt/Bus | No |
| 3/9/2009 | PA-42 | Aircraft landed hard at Farmingdale Airport, NY | N.A. | Landing | Comm | No |
| 3/22/2009 | PC-12 | Acft. pitched over on final VFR app. 7 adults, 7 children fatal | N.A. | Approach | Corp | Yes |
| 3/22/2009 | BE-200 | Wing struck tree during taxi, Henderson, NV | N.A. | Taxi | Comm | No |
| 4/1/2009 | CE-208B | Aircraft damaged during forced landing, unknown cause | N.A. | Landing | Comm | No |
| 4/12/2009 | BE-90L | Aircraft landed with landing gear retracted | N.A. | Landing | Pvt/Bus | No |
| 4/21/2009 | CE-208 | Engine caught fire during landing roll 6 hours after overhaul | N.A. | Landing | Corp | No |
| 5/25/2009 | BE-90C | Aircraft experienced engine problems and landed in a field | N.A. | Approach | Comm | No |
| 6/12/2009 | PC-12 | Aircraft landed long and overran runway | N.A. | Landing | Frax | No |
| 6/22/2009 | BE-100A | Rt. main landing gear failed to extend, crew landed gear up | N.A. | Landing | Comm | No |
| 7/2/2009 | PA-46TPCvn | Aircraft landed with landing gear retracted | N.A. | Landing | Pvt/Bus | No |
| 7/3/2009 | CE-441 | Gear failed to extend, crew landed with gear retracted | N.A. | Landing | Comm | No |
| 7/5/2009 | PC-12 | Pilot said, "lost panel". avoiding storms, control lost, crashed | N.A. | Cruise | Pvt/Bus | Yes |
| 7/9/2009 | PA-46TPCvn | Aircraft landed with landing gear retracted, day, VMC | N.A. | Landing | Pvt/Bus | No |
| 7/21/2009 | BE-100 | Crew failed to extend landing gear, while avoiding wake turb | N.A. | Landing | Comm | No |
| 7/23/2009 | BE-C90A | Cabin door opened on takeoff, aircraft landed safely | N.A. | Takeoff | Corp | No |

# Appendix B

## 2009 Business Turbo Prop Accidents (North American Registered) Con't

| Date | Model | Description | Region | Phase | Operator | Fatalities |
|---|---|---|---|---|---|---|
| 8/1/2009 | BE-B90 | Sky diver fell out of aircraft and struck stabilizer, fatally injured | N.A. | Cruise | Pvt/Bus | Yes |
| 8/17/2009 | AC-690A | Aircraft clipped trees during approach | N.A. | Approach | Pvt/Bus | No |
| 8/29/2009 | TBM-700 | Reportedly aircraft landed hard in gusting winds, 300/13/22kts | N.A. | Landing | Pvt/Bus | No |
| 9/8/2009 | BE-200 | Gear failed to retract and collapsed during landing | N.A. | Landing | Corp | No |
| 9/10/2009 | CE-208 | Aircraft flipped over during taxi | N.A. | Taxi | Comm | No |
| 9/15/2009 | CE-208 | Engine fire in flight, forced off airport landing in field | N.A. | Climb | Comm | No |
| 9/16/2009 | BE-200B | Aircraft veered on initial climb and impacted terrain | N.A. | Climb | Corp | No |
| 10/6/2009 | BE-100 | Aircraft reported an engine problem and forced landed in a field | N.A. | Landing | Pvt/Bus | No |
| 10/15/2009 | CE-208B | Acft. tipped on tail due improper loading and aft e.g., parked | N.A. | Parked | Comm | No |
| 10/16/2009 | P-180 | Forced landing due wx. and fuel exhaustion on ice cap | N.A. | Landing | Comm | No |
| 10/21/2009 | AC-690 | Right main gear collapsed during landing | N.A. | Landing | Pvt/Bus | No |
| 10/26/2009 | BE-B100 | Aircraft crashed after encountering severe thunderstorm activity | N.A. | Maneuver | Pvt/Bus | Yes |
| 11/9/2009 | BE-200 | Aircraft crash landed short of the runway due power loss, VMC | N.A. | Approach | Corp | No |
| 12/4/2009 | PA-31T2 | Aircraft collided with terrain after control loss at altitude | N.A. | Descent | Pvt/Bus | Yes |
| 12/7/2009 | PA-46-500TP | Control lost while being vectored to ILS in IMC | N.A. | Approach | Pvt/Bus | Yes |
| 12/9/2009 | BE-100A | Aircraft crashed during approach, night, IMC | N.A. | Approach | Comm | Yes |
| 12/13/2009 | TBM-700 | Aircraft stalled following landing abort in marginal weather | N.A. | Landing | Pvt/Bus | No |
| 12/22/2009 | BE-E90 | Pilot retracted landing gear instead of flaps during landing | N.A. | Landing | Comm | No |

# Appendix B

## 2009 Business Turbo Prop Accidents (Non-North American Registered)

| Date | Model | Description | Region | Phase | Operator | Fatalities |
|---|---|---|---|---|---|---|
| 1/4/2009 | AC-690 | Damaged when hangar door blew onto aircraft | Africa | Static | Corp | No |
| 1/19/2009 | PA-42C | Aircraft crashed in mountainous terrain in poor weather | Europe | Cruise | Comm | Yes |
| 1/21/2009 | BE-F90 | Pilot attempted late go-around. Acft. settled gear up on ground | Africa | Approach | Comm | No |
| 2/7/2009 | EMB-110 | Aircraft crash landed after loosing power in heavy rain/wx. | S.A. | Approach | Comm | Yes |
| 2/11/2009 | CE-208B | Landing gear collapsed landing and fire destroyed aircraft | Africa | Landing | Comm | No |
| 2/11/2009 | BE-200 | Nose gear failed to extend by any means, acft lded on mains | Europe | Landing | Corp | No |
| 2/18/2009 | DC-3TP | A loose grenade discharged in the cabin during boarding | S.A. | Static | Public | No |
| 3/1/2009 | BE-100 | Acft. descended into high terrain on initial app. VFR in poor wx. | S.A. | Descent | Comm | Yes |
| 3/2/2009 | AC-690C | Aircraft set on fire while parked, drug related, Guatemala | S.A. | Static | – | No |
| 3/4/2009 | CE-208B | Aircraft overshot engine out landing, following takeoff | Africa | Landing | Comm | No |
| 3/7/2009 | AC-690 | Gear failed to extend, gear up landing followed | S.A. | Landing | Comm | No |
| 3/19/2009 | BE-200 | Aircraft impacted upper floors of a building on approach in fog | S.A. | Approach | Military | Yes |
| 4/1/2009 | EMB-110 | Aircraft failed to become airborne from soft unsurfaced runway | Africa | Takeoff | Comm | No |
| 4/11/2009 | CE-208B | Power malf/failure in flight, damaged in forced landing | Asia | Landing | Comm | No |
| 4/17/2009 | CE-208B | Aircraft collided with power line during takeoff in VMC | S.A. | Takeoff | Comm | Yes |
| 5/23/2009 | BE-350 | Aircraft crashed 600 ft. short of runway, approaching in IMC | S.A. | Approach | Corp | Yes |
| 6/10/2009 | BE-200C | Nose gear failed to lock down,, collapsed on landing | Africa | Landing | Comm | No |
| 6/13/2009 | BE-90C | Landing gear struck a car roof during approach in IMC | S.A. | Approach | Corp | No |
| 6/29/2009 | DHC-6 | Aircraft crashed into a mountain in heavy cloud and rain | Asia | Maneuver | Comm | Yes |
| 7/3/2009 | BE-90C | Right main gear collapsed during landing | Africa | Landing | Comm | No |
| 7/19/2009 | BE-C90 | Cabin door opened and separated during climb, acft. landed ok | S.A. | Climb | Comm | No |
| 8/2/2009 | PA-46TPCvn | Aircraft landed with nose gear retracted. A PA-46TP conversion | Europe | Landing | Comm | No |
| 8/14/2009 | BE-99 | Aircraft impacted building during a day VMC go around | Europe | Approach | Comm | Yes |
| 8/26/2009 | CE-208B | Power loss cruise, aircraft ditched in water, on sched. pax. fit | S.A. | Cruise | Comm | No |

# Appendix B

## 2009 Business Turbo Prop Accidents (Non-North American Registered) Con't and Large Air Carrier

| Date | Model | Description | Region | Phase | Operator | Fatalities |
|---|---|---|---|---|---|---|
| 10/16/2009 | PC-12 | Crashed after takeoff, possible engine fire reported | Europe | Climb | Pvt/Bus | Yes |
| 11/8/2009 | SA-227AC | Aircraft damaged during a hard landing | Europe | Landing | Comm | No |
| 11/9/2009 | BE-1900 | On returning to land for unkn.reason, aircraft undershot rwy. | Africa | Landing | Comm | Yes |
| 11/10/2009 | PA-46TCvn | Landing gear collapsed during landing, day VMC existed | Africa | Landing | Pvt/Bus | No |
| 11/11/2009 | CE-208B | Aircraft failed to climb after takeoff without flaps extended | Africa | Climb | Comm | Yes |
| 12/7/2009 | BE-F90 | Aircraft impacted terrain on final approach in IMC | Europe | Approach | Comm | Yes |
| 12/11/2009 | BE-350 | Aircrafts wing, engine and propeller damaged during landing | Asia | Landing | Comm | No |
| 12/20/2009 | SA-227AC | Gear failed to extend, pilot landed with gear retracted | C.A. | Landing | Comm | No |

### 2009 Large Air Carrier Jet and Turboprop Accidents

| Date | Model | Description | Region | Phase | Fatalities |
|---|---|---|---|---|---|
| 1/5/2009 | DC-3TP | Pilot inadvertently hit ground during a low pass in VMC | N.A. | Maneuver | No |
| 2/4/2009 | DHC-6 | Directional control lost on landing, acft.hit trees, stopped | N.A. | Landing | No |
| 2/14/2009 | CASA | Aircraft undershot runway in marginal weather | N.A. | Approach | No |
| 4/92009 | BAe-146 | Aircraft flew into high terrain during 2nd approach in IMC | Asia | Approach | Yes |
| 4/17/2009 | PC-6B | Aircraft flew into terrain, day, marginal weather | Asia | Descent | Yes |
| 7/29/2009 | DHC-6 | Aircraft landed hard due to down drafts at small strip | Europe | Landing | No |
| 8/11/2009 | DHC-6 | Aircraft flew into terrain attempting VMC in IMC | Oceania | Manuever | Yes |
| 9/18/2009 | CASA | Control lost during landing in gusts, rain, minimum ceiling | Oceania | Manuever | No |
| 10/22/2009 | DO-228 | Aircraft landed with landing gear retracted | Asia | Landing | No |
| 12/19/2009 | HS-748 | Runway overshoot on sand runway following tire failure | Africa | Landing | Yes |
| 12/29/2009 | DC-3TP | Aircraft overturned landing on water on floats, gear down | Oceania | Landing | No |

# Appendix C

## Methodology

### 1. Annual Accident Assessment

IBAC contracts annually to Robert Breiling and Associates to assess and collate business aviation accidents. The Breiling Report provides IBAC with operating hours for each aircraft type as well as accident statistics by aircraft type, by operator type and by area of the world. IBAC uses the information to publish a summary report in the annual *Business Aviation Safety Brief*.

To date the Brief has provided only limited information on accident by operator type due to the lack of acceptable exposure data in terms of hours of operation for each operator type.

It has always been recognized that achieving safety improvement is highly reliant on the knowledge base and understanding of the operations of greater risk so that mitigation can be determined and applied. As an indicator applied to assessing risk, business aviation places importance on statistical comparisons of the accident rate between the different business aviation operational types, namely accident rates for operations of corporate aviation, on-demand commercial and owner operated. Given the difficulty in obtaining exposure data for the hours attributed to each operational type, in the past it has been difficult to obtain with any degree of confidence the accident rates for each operation. However, with recent changes in the methodology and accuracy of an annual survey of general aviation and on-demand Part 135 operators by the US Federal Aviation Administration, IBAC has now concluded that data developed from the Survey is sufficiently accurate to serve as a methodology to provide a global perspective of the difference in rates between the operator types.

**Percentage of Operations by Operator Type**

The following distribution by operator type is applied to the business aviation hour and departure data to determine exposure by operator used to calculate accident rates: (See Attachment for methodology)

| | Jet Average | TP Average | Total |
|---|---|---|---|
| **Corporate** | 60.7% | 43.2% | 55.3% |
| **Owner Operator** | 11.3% | 21.1% | 14.3% |
| **Commercial On-Demand** | 28.0% | 35.7% | 30.4% |

**Table C-1**

## 2. Availability of Exposure Data

The US FAA annually completes a survey of US operators, including hours of flight by operator type. Prior to 2006 IBAC was concerned that the gap between the total flying hours calculated by Robert Breiling was different from those of the FAA. However, over the last couple of years the gap has closed to the point that there is increased confidence in the survey results and IBAC has now concluded that the survey information is sufficiently accurate to provide a reasonable assessment of the differences between accident rates for each operator type.

The FAA survey is sent to 100% of general aviation and on-demand commercial operators of turbine aircraft in the US and follows up three times with operators that do not respond immediately. Submissions are made annually by approximately 45% of the US turbine operator population. The US business aviation fleet consists of 65% of the world fleet and the distribution between operator types is considered representative of the global fleet with the exception of the European fleet. The global distribution and an assessment of each region is as follows;

| | | |
|---|---|---|
| United States | 65% | |
| North America without the US | 8% | Distribution considered similar to the US |
| South America | 7% | Distribution considered similar to the US |
| Europe | 11% | Probable higher percent of on-demand commercial operations. |
| Rest of the World | 9% | Different rule structures but most would be similar to the US |

FAA survey data was applied over a three year period to develop an average distribution by aircraft type (Jet, Turbo-Prop and Combined) and operator type (Commercial On-demand, Corporate and Owner-Operated). The data in Table C-1 was applied to the total business aviation hours to calculate the number of flying hours for each operational type.

## 3. Rate Calculation

Accident rates per operator type were calculated using accident data in the Safety Brief, along with exposure data as explained in S2 above. Tables were developed for both 100,000 flying hours and 100,000 departures.

## 4. Assumptions

IBAC recognizes that there is error built into the methodology, but given the lack of options the data is considered as accurate as anything available. The following assumptions that give rise to some error are:

The breakdown by operator types is derived from an FAA survey of US operators. An assumption is made that the remainder of the world will have an operator distribution similar to the US. Given that the US consists of approximately 65% of the global fleet, it is unlikely that the error due to this assumption will be very significant.

The FAA survey captured approximately 50% of the total global flying hours. It is assumed that the 50% is representative of the distribution for the complete population.

## 5. Sensitivity Analysis

As noted above, an assumption is made that the US distribution by operator type is representative of the global fleet distribution and yet it was also concluded that the European fleet distribution is likely different than that of the US. Given the potential that this may result in an unacceptable error, a sensitivity analysis was completed to determine the impact of a higher percentage of the European fleet being operated as on-demand charters.

Two samples for European distribution were selected to test the impact.

| Operator Type | Baseline per US Survey | Sample 1 | Sample 2 |
|---|---|---|---|
| Commercial On-Demand | 31% | 60% | 70% |
| Corporate | 55% | 30% | 25% |
| Owner Operated | 14% | 10% | 5% |

Results of the analysis demonstrate a very small change when the sample data for Europe is applied. Typically, the sensitivity analysis tables conclude a difference ranging from .01% to .08% in the fatal accident rates, which demonstrates acceptable level of error for the comparison purposes intended by the statistics.

The following Table shows the results of applying to the Safety Brief Issue 6 data the two Sample distributions to the combined jet and turbo-prop fleets.

| | **Baseline** (31/55/14 %) | | **Sample 1** (Europe 60/30/10 %) | | **Sample 2** (Europe 70/25/5 %) | |
|---|---|---|---|---|---|---|
| | Total | Fatal | Total | Fatal | Total | Fatal |
| **Commercial On-demand** | 2.28 | 0.66 | 2.48 | 0.71 | 2.58 | 0.74 |
| **Corporate** | 0.18 | 0.04 | 0.19 | 0.04 | 0.19 | 0.04 |
| **Owner Operated** | 1.86 | 0.64 | 1.85 | 0.63 | 1.92 | 0.64 |
| **Combined** | 1.08 | 0.31 | 1.08 | 0.31 | 1.08 | 0.31 |